Recent Legislation

Water Resources Planning Act, 1965 (P.L. 89-90)
This law created the U.S. Water Resources Council, an independent executive agency that encourages the conservation, development, and use of water and related land resources on a comprehensive and coordinated basis. The chief tool in carrying out this mission is the establishment of the Unified National Program for Floodplain Management, which provides administrative guidelines that are applicable nationally to all levels of government and the private sector. This document, first issued in 1976 and revised and reissued in 1979, analyzes the basic principles of flooding and relates both riverine and coastal floodplains to the natural and social systems of which they are a part. Based on this analysis, it then outlines a series of management strategies, implementation techniques, and recommendations for an effective response to floods.

National Flood Insurance Act, 1968 (P.L. 90-448, Title 13)
This act set up a joint public/private National Flood Insurance Program (NFIP), with the important provision that insurance is available to individuals only if their community has an approved floodplain ordinance in conjunction with a floodplain management program. The effect is to shift part of the responsibility for flood damage reduction to local governments and to provide an incentive for floodplain regulation.

A 1969 amendment to this legislation made the NFIP more practicable by setting up an emergency insurance program for communities that lacked the information necessary for floodplain regulation. Once the required studies are completed and floodplain management is being implemented, the community moves to the regular insurance program. (These regulations are detailed in the following chapter.)

There are currently about 11,500 communities in the NFIP emergency program and over 5,000 in the regular program. Conversions from emergency to regular are occurring at a rate of approximately 1,000 communities a year.

Flood Disaster Protection Act, 1973 (P.L. 93-234)
In effect, this legislation changed the NFIP from a voluntary to a mandatory program. It achieved this by requiring purchase of flood insurance for any federal project and, more significantly, any project in a flood-prone area that relies on federal mortgage guarantees. This tied flood insurance to any building that was financed with assistance of Federal Housing Administration and Veterans Housing Administration loans, or for which a loan was guaranteed by the Federal Deposit Insurance Corporation or the Federal Savings and Loan Insurance Corporation. It also prohibited payment of disaster funds, except for emergency relief, in communities that were not participating in the NFIP.

Disaster Relief Acts, 1970 and 1974 (P.L. 91-606 and 93-228)
The first of these acts set up a disaster relief program to assist areas that have suffered major damage during a natural disaster. The program is managed by the Disaster Response and Recovery Office, a part of the Federal Emergency Management Agency (FEMA). The second act supplemented the first by requiring hazard mitigation actions, either before or after a disaster, as a condition for receipt of disaster relief funds.

vent floods, the new emphasis was on the need to correct many of the imbalances that resulted from the conflicts between the natural and the built environments and that had precipitated escalating losses.

In 1965 Congress passed the first of a succession of laws updating federal flood policy. The effect of this policy evolution was not to eliminate flood control as a strategy, but to shift much of the emphasis of federal programs to nonstructural strategies. It also required greater involvement by local governments, put more attention on protecting the natural environment, increased the attention given to coastal flooding, and redistributed some of the financial burden of flood losses from the general public to the individual users of flood-prone property.

Executive Orders

Presidential Executive Orders concerning flooding were issued in 1967 and 1977. These interpret and reinforce the intent of the legislative acts as they are implemented by the appropriate executive agencies.

- E.O. 11296, issued in 1967, required evaluation of flood hazards in connection with any proposed action by a federal agency. The order was supplanted in 1977 by E.O. 11988, *Floodplain Management,* which advocates protection of floodplains as natural phenomena and provides explicit support for nonstructural measures wherever they are feasible.

It is significant that the Executive Order 11988 applies to all federally funded construction and development, including that funded by Community Development Block Grants. The Executive Order actually calls for higher standards than the National Flood Insurance Act, thus putting federal agencies in a leadership position regarding floodplain management.

- E.O. 11990, *Wetlands,* also issued in 1977, requires all agencies to act to minimize the destruction, loss, or degradation of natural wetlands.

Strategies for Flood Damage Reduction

As mentioned above, the emphasis of federal flood policy has shifted from almost exclusive use of structural control measures to equal consideration of nonstructural strategies. Included in this new approach are a number of methods, each supporting and supplementing the others.

It is now recognized that the various approaches must be combined to fit the unique circumstances of any given situation. Flood control is effective under some conditions, but cannot succeed alone. Water and land resources should be regulated to complement structural controls. Warning systems should be devised or refined. Individual buildings should be protected as necessary.

The coordinated use of the full range of strategies is essential to achieving a significant reduction in flood losses. Following is a brief review of the nonstructural methods that have emerged in recent years.

Land-Use Planning and Management

The principal nonstructural strategy for reducing flood damage is to effect better use of water and land resources. This goal is achieved through comprehensive planning for and management of these resources throughout riverine watersheds and coastal environs.

Planning and management, as a strategy to reduce flood damage, addresses the critical need to better integrate the natural and built environments. This approach to the problems of flooding is based on the knowledge that, while floods cannot and should not be totally eliminated, the built environment can nevertheless be successfully developed if it respects the natural system.

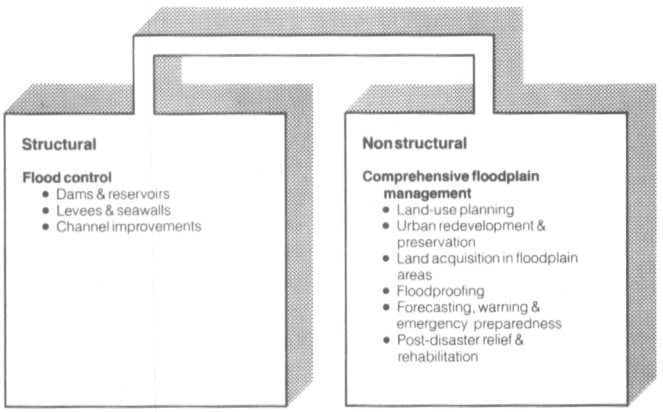
Planning and management, in practice, are based on compiling technical data on topography, drainage, soil composition, climate, and other natural characteristics and analyzing it in light of the physical, social, and economic aspects of the built environment. This analysis is then used to determine appropriate locations for both the encouragement and prohibition of building. Implementation then relies on regulations, such as zoning ordinances, subdivision regulations, and health and building codes, or on incentives that induce positive development practices. Floodplain management objectives can also be realized in conjunction with programs for urban revitalization and preservation, or through land acquisition by public bodies to control development.

Urban Redevelopment and Preservation

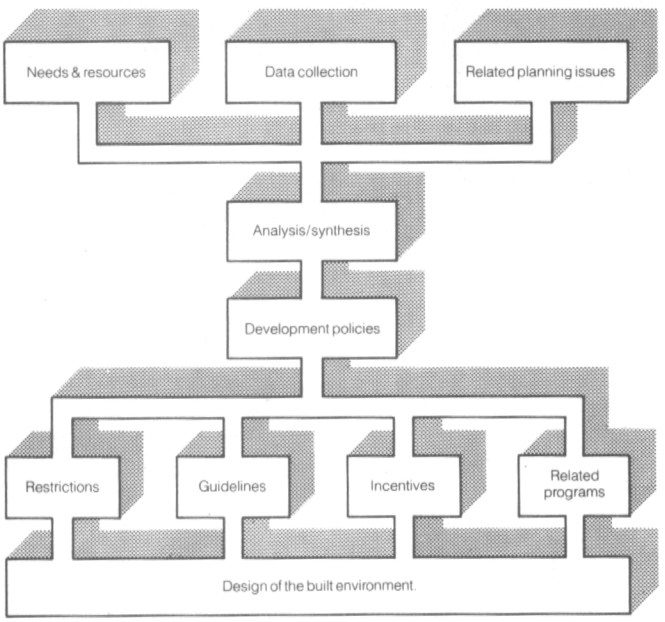
Renewal of the nation's cities is by its nature a continuous process. It offers the opportunity to rectify many of the earlier development practices that have contributed to flood damage. In some cases land that is particularly vulnerable to flooding can be cleared by "down-zoning" it to open space uses. In many cases, however, economic constraints or the historical significance of a building or district can make this impossible.

When renewal is to occur, design and development can make use of site design and floodproofing strategies to lessen the impact of flooding. Obviously, there is more latitude when working with a cleared site, but these strategies can also be applied to existing buildings.

Historical preservation is often a high priority in rehabilitation. Schemes to preserve important cultural artifacts require careful and creative use of damage reduction strategies to make a building safer from flood damage while respecting the integrity of the original design.



The floodplain planning process allows careful consideration of the various issues related to floods, resulting in the regulation and guidance of design and development.



Urban redevelopment and preservation in flood-prone areas offer opportunities to rectify many of the development practices that contributed to flood damage in the past. Such projects can use site design and floodproofing strategies to lessen the impact of flooding.

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Acquisition and Relocation

In many flood-prone areas existing development suffers repeated damage. Often such locations can be protected only by removing development, but this can rarely be accomplished without public ownership of the land. Public ownership is, likewise, the surest way to protect vacant land that is subject to development pressure.

A growing number of public bodies recognize the desirability of both acquiring such hazardous sites, either through negotiation or eminent domain, and relocating existing uses to safer sites. This strategy mitigates recurring losses, helps to restore natural processes in the floodplain, and promotes open space uses such as agriculture or recreation.

Federal authority to implement such policies exists in several forms. Section 1362 of the National Flood Insurance Act allows the Federal Emergency Management Agency (FEMA) to acquire certain flood-prone sites. To qualify, properties must meet several criteria—they must be insured, they must be substantially damaged or repeatedly flooded, and the relevant local government must be willing to take the property under its control. Implementation of Section 1362 has been slow, partly because of the constraints described above and partly because of a lack of funding. Fiscal year 1980 was the first time that funds were available specifically for Section 1362 acquisitions, with over $5 million used for that purpose in that year.

Earlier acquisition and relocation projects have been carried out using a variety of other funding sources. A project to relocate the business district of Soldier's Grove, Wisconsin, out of a riverine floodway has been initiated using discretionary funds available to the Departments of Interior and Housing and Urban Development and a grant from the Economic Development Administration. Section 73 of the 1974 Water Resources Development Act (P.L. 93-251) provides for acquisition and relocation, and

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several programs are underway. For example, in Prairie du Chien, Wisconsin, the U.S. Army Corps of Engineers is in the process of moving both residential and commercial buildings out of a highly vulnerable floodplain.

The scope of acquisition can vary widely. Following the devastating flash flood of 1972 in Rapid City, South Dakota, the entire floodway of Rapid Creek was acquired and cleared for open space. A local effort in Baltimore County, Maryland, purchased more than 200 dwellings that were located in the floodplain of several suburban streams. In Littleton, Colorado, the Corps of Engineers purchased 750 acres of land downstream from a reservoir to protect it from urban expansion. Other such projects are gaining momentum as funding sources are identified.

Floodproofing

Despite floodplain management and related programs to remove structures from hazardous locations, buildings will inevitably continue to be located in such areas. It is necessary that these buildings be protected from flood damage. Floodproofing, working in conjunction with floodplain management, provides this kind of protection.

Floodproofing encompasses any technique intended to protect buildings from flooding, and typically includes elevating buildings above the flood hazard level, providing watertight closures for doors and windows, and using floodwalls around ground level openings or, alternatively, eliminating such openings. Also included are the use of water-resistant materials, structural reinforcement to withstand water pressures, and placement of mechanical elements in the upper parts of buildings.

Floodproofing is applicable to historic buildings, to essential uses that are not suitable for alternative locations, and to areas in which the capital investment in the existing urban infrastructure requires continued occupation of a hazardous location. In these situations flood-

U.S. Army Corps of Engineers

Some existing development cannot be effectively protected from flooding. Recently, federal programs have been used to acquire these properties and relocate them in safe areas. Above is a portion of Prairie du Chien, Wisconsin (within circle), that was relocated by the Corps of Engineers.

proofing can be indispensable. Floodproofing is especially suitable where moderate flooding with low stage, low velocity, and short duration is experienced.

Forecasting, Warning, and Emergency Preparedness

Forecasting, warning, and emergency preparedness measures are integral parts of a well-balanced floodplain management system. For example, adequate warning allows time for the preparation of temporary floodproofing closures and the evacuation of people and building contents from hazardous locations. This is, in part, a technical issue of concern to meteorologists and hydrologists and, in part, an administrative issue requiring a system of emergency planning, organization, communication, and public education.

Relief and Rehabilitation

Relief and rehabilitation are, in the first instance, not methods of reducing flood damage, but ways of dealing with damage after other measures have been insufficient. Relief and rehabilitation assistance can include direct clean-up operations as well as loans, grants, and tax reductions to facilitate rebuilding and relocating where necessary. Federal agencies are the primary source of this aid, with private support available from organizations such as the Red Cross.

Rehabilitation can provide important damage mitigation opportunities. When rehabilitation is necessitated by flood disaster, future flood losses can be reduced by ameliorating many of the problems that contributed to destruction. There are often strong local pressures to rebuild as quickly as possible, particularly where economic livelihood is involved. And such pressures are justified. Yet, just as often there are long-term economic and social reasons for breaking the cycle of repeated destruction and ensuring that earlier development mistakes are not duplicated.

Post-disaster rehabilitation is most effective if it responds quickly to the needs of local residents but minimizes future destruction. This requires that redevelopment proceed according to sound principles of floodplain management, taking advantage of the various methods for reducing flood damage that apply to new development.

Experience has shown that any needed improvements in structural flood control devices should be seen as supplementary to the nonstructural measures now available. Changes in land use, acquisition and relocation of flood-prone properties, and appropriate floodproofing protection for buildings should all be used in the rebuilding effort. This comprehensive approach requires planning and coordination, which is properly the role of

U.S. Geological Survey

Small-scale dikes can be constructed as part of an emergency preparedness plan. The sand-bag dike is protecting the houses from flood damage.

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When flooding occurs, relief programs include the inevitable clean-up as well as assistance to victims of the disaster.

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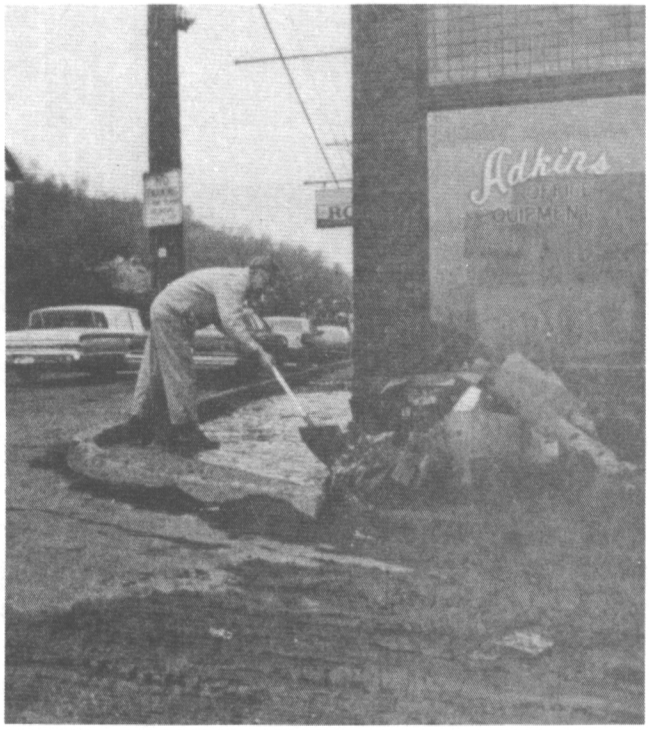

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government agencies, but also needs the cooperation and support of all participants in the redevelopment process.

The issues and methods discussed in this and the preceding chapter must be integrated into the process of development. The remaining chapters will tie flood problems more specifically to one of the crucial components of development, design of the built environment.

Literature Resources

Coastal Flood Hazards and the National Flood Insurance Program. H. Crane Miller. Washington, D.C.: Federal Insurance Administration, 1978.

Evaluation of the Economic, Social, and Environmental Effects of Floodplain Regulations. Sheaffer and Roland, Inc. Washington, D.C.: Federal Insurance Administration, 1979.

Flood-Prone Areas and Land Use Planning. A. O. Waananen, et. al. Washington, D.C.: U.S. Geological Survey, 1977.

Options to Improve Federal Nonstructural Response to Floods. Rutherford H. Platt. Washington, D.C.: U.S. Water Resources Council, 1979.

Regulations for Flood Plains. Jon A. Kusler. Chicago: American Society of Planning Officials, 1972.

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Unified National Program for Flood Plain Management. Washington, D.C.: U.S. Water Resources Council, 1979.

Chapter 4

Design Analysis for Flood Damage Reduction

Achieving a significant reduction in current levels of flood damage requires attention to all aspects of the development process, from structural flood control to floodplain management to design of the built environment. Designers are principally involved in the latter, with their necessary response being the explicit inclusion of damage reduction strategies in the design process. Such action requires that they first be aware of regulatory restrictions and guidelines, site-specific flooding characteristics, and appropriate techniques for mitigating flood damage through project design.

Previous chapters discuss the general relationship between flooding and the built environment. This chapter examines the specific information the designer needs for projects in flood-prone areas. This information is used in pre-design project analysis, both to ascertain basic flood hazards and to ensure that the project meets relevant regulatory requirements. The concluding chapter explores the associated techniques that are applied during development of the actual design.

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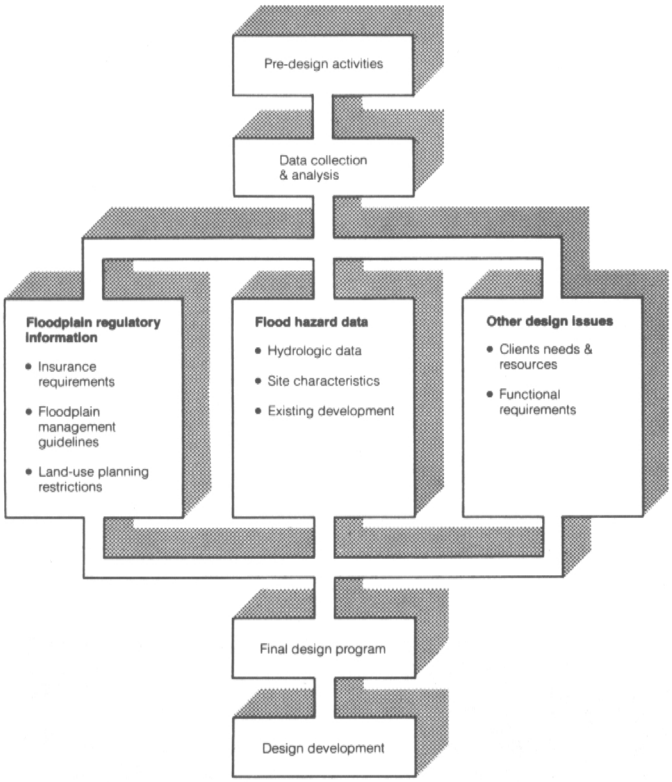


The design process must include analysis of floodplain regulatory information and flood hazard data.

The development process involves a wide range of decisions that directly influence the subsequent design of any project. The designer's role in making these decisions varies according to the nature of any given project, but generally centers on project analysis and evaluation. This phase culminates in the design program, which identifies problems and issues and sets out the requirements and criteria that will guide the generation of appropriate design responses. It is essential that analysis of flooding issues be part of this pre-design phase.

As with any aspect of a design problem, the starting point in analyzing the potential effects of flooding on a project is the collection and analysis of pertinent data. This research adds the necessary technical information to the client's initial program of needs and resources, thus making the connection between the individual site and the larger context of natural systems and the existing built environment.

Project analysis first requires knowledge of what data to collect, why it is important, and where it can be obtained. Analysis should identify the interaction of components in the natural and built environments and the relationship of these components to design of the proposed project.

The following sections identify the data relevant to flood damage reduction, outline the importance of the data, and review potential data sources. Pertinent data is categorized first according to the variety of flood-related regulatory programs and then according to specific flood hazard data.

Regulatory Information

A number of local, state, and federal requirements apply to development in flood-prone areas, foremost of which are a variety of programs for floodplain management. Part of the pre-design collection and analysis of information should include identification of these regulatory requirements and assessment of their constraints and opportunities.

National Flood Insurance Program

A primary impetus for mitigating flood damage comes from the National Flood Insurance Program (NFIP), which was established by Congress in 1968 to reduce the losses associated with flood damage. Administered by the Federal Emergency Management Agency (FEMA), this program's primary component is a stipulation that flood insurance is available only in communities that have satisfied federal requirements for floodplain management. This stipulation serves as an incentive to local governments to undertake appropriate planning measures to

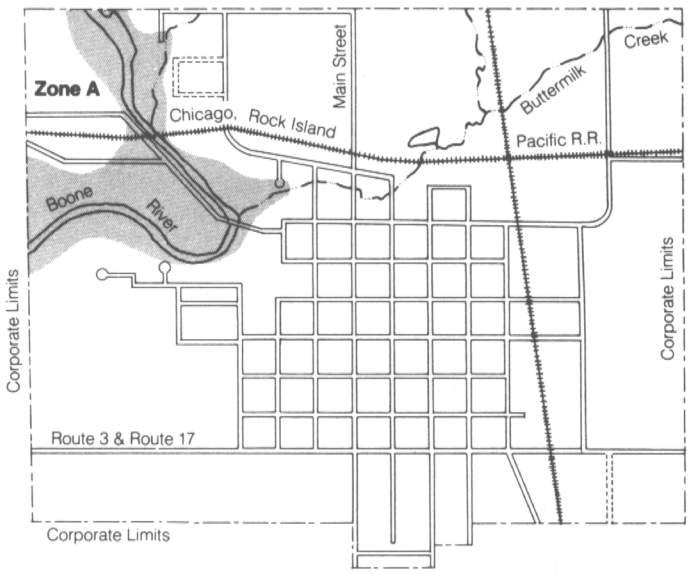
reduce flood losses by regulating development in hazardous areas. In addition to the planning incentive, the intent of the NFIP is expressed through insurance rate differentials and financial restrictions on federally guaranteed loans.

Emergency Program. Insurance regulations governing the NFIP vary according to the status of an individual community's floodplain regulatory process. When the available data on local flood hazards is insufficient to support final regulations, the community enters the "emergency phase," which provides limited insurance coverage with a large subsidy. A community may enter this emergency phase prior to completion of a detailed flood hazard survey. The local government, relying on an initial Flood Hazard Boundary Map, must adopt preliminary regulations to encourage proper development practices in flood-prone areas.

Regular Program. After the completion of detailed surveys (which are funded by FEMA), the resulting technical studies allow more comprehensive regulations. These technical reports identify pertinent information such as base flood elevations, areas inundated by various magnitudes of flooding, floodway boundaries, and coastal high hazard areas. This information is provided in the form of Flood Insurance Rate Maps, Flood Boundary Maps, and Floodway Maps.

Flood Hazard Boundary Map FHBM

City of Floodville, Pennsylvania Flood County



Zone A Areas of Special Flood Hazard

Note: These maps may not include all Areas of Special Flood Hazard in the community. After a more detailed study, the areas shown on this map may be modified and other areas added.

Flood Hazard Boundary Maps like this one are used as the basis of preliminary floodplain regulations in the emergency phase of the National Flood Insurance Program.

Flood Insurance Rate Map

ELEVATION REFERENCE MARKS

REFERENCE MARK	ELEVATION (FEET NGVD)	DESCRIPTION OF LOCATION
RM1	889.70	U.S. Geological Survey standard brass disk, stamped „Erie 1934" set in top of concrete post flush with ground located in the city park, 4.7 feet north of the centerline of Third Street, 146 feet east of the centerline of Butler Street.
RM2	890.23	Top of southwestern bolt on the top flange of fire hydrant at northeast corner of the intersection of Fifth Street and Massachusetts Street.
RM3	889.36	Top of railroad spike projecting from north side of power pole, approximately one foot above the ground, located at northwest corner of intersection of Seventh Street and Massachusetts Street.
RM4	891.21	Top of west bolt on the top flange of fire hydrant at southeast corner of the intersection of Wilder Street and Butler Street.
RM5	894.25	Top of southeastern bolt on the top flange of fire hydrant at southwest corner of intersection of State Street and Butler Street.
RM6	902.12	Top of southwestern bolt on the top flange of fire hydrant at southeast corner of intersection of Railroad Street and Butler Street.
RM7	889.53	Chiseled cross on east end of south headwall of Second Street over the Tributary to Puckets Run Creek.
RM8	892.68	Top of railroad spike head projecting from north side of power pole, approximately one foot above the ground, located at southeast corner of intersection of Canville Street and the Missouri, Kansas, Texas railroad tracks.

KEY TO MAP

500-Year Flood Boundary
100-Year Flood Boundary
Zone Designations* With Date of Identification e.g., 12/2/74
100-Year Flood Boundary
500-Year Flood Boundary

Base Flood Elevation Line With Elevation in Feet** — 513
Base Flood Elevation in Feet Where Uniform Within Zone** — (EL 987)
Elevation Reference Mark — $RM7_x$
River Mile — ● M1.5

**Referended to the National Geodetic Vertical Datum of 1929

*EXPLANATION OF ZONE DESIGNATIONS

ZONE	EXPLANATION
A	Areas of 100-year flood; base flood elevations and flood hazard factors not determined.
A0	Areas of 100-year shallow flooding where depths are between one (1) and three (3) feet; average depths of inundation are shown, but no flood hazard factors are determined.
AH	Areas of 100-year shallow flooding where depths are between one (1) and three (3) feet; base flood elevations are shown, but no flood hazard factors are determined.
A1-A30	Areas of 100-year flood; base flood elevations and flood hazard factors determined.
A99	Areas of 100-year flood to be protected by flood protection system under construction; base flood elevations and flood hazard factors not determined.
B	Areas between limits of the 100-year flood and 500-year flood; or certain areas subject to 100-year flooding with average depths less than one (1) foot or where the contributing drainage area is less than one square mile; or areas protected by levees from the base flood. (Medium shading)
C	Areas of minimal flooding. (No shading)
D	Areas of undetermined, but possible, flood hazards.
V	Areas of 100-year coastal flood with velocity (wave action); base flood elevations and flood hazard factors not determined.
V1-V30	Areas of 100-year coastal flood with velocity (wave action); base flood elevations and flood hazard factors determined.

NOTES TO USER

Certain areas not in the special flood hazard areas (zones A and V) may be protected by flood control structures.

This map is for flood insurance purposes only; it does not necessarily show all areas subject to flooding in the community or all planimetric features outside special flood hazard areas.

For adjoining map panels, see separately printed Index To Map Panels.

INITIAL IDENTIFICATION – JUNE 28, 1974
CONVERSION TO REGULAR PROGRAM – FEBRUARY 15, 1979

Refer to the CONVERSION TO REGULAR PROGRAM date shown on this map to determine when actuarial rates apply to structures in the zones where elevations or depths have been established.

To determine if flood insurance is available in this community, contact your insurance agent, or call the National Flood Insurance Program, at (800) 638-6620, or (800) 424-8872.

Flood Boundary and Floodway Map

ELEVATION REFERENCE MARKS

REFERENCE MARK	ELEVATION (FEET NGVD)	DESCRIPTION OF LOCATION
RM1	889.70	U.S. Geological Survey standard brass disk, stamped „Erie 1934" set in top of concrete post flush with ground located in the city park, 4.7 feet north of the centerline of Third Street, 146 feet east of the centerline of Butler Street.
RM2	890.23	Top of southwestern bolt on the top flange of fire hydrant at northeast corner of the intersection of Fifth Street and Massachusetts Street.
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RM8	892.68	Top of railroad spike head projecting from north side of power pole, approximately one foot above the ground, located at southeast corner of intersection of Canville Street and the Missouri, Kansas, Texas railroad tracks.

KEY TO MAP

500-Year Flood Boundary
100-Year Flood Boundary
FLOOD FRINGE
100-Year Flood Boundary
500-Year Flood Boundary
Approximate 100-Year Flood Boundary
Cross Section Line

Elevation Reference Mark — $RM7_x$
River Mile — ● M1.5

NOTES TO USER

Boundaries of the floodways were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations without regard to economic, legal, or political factors.

This map was prepared to support minimum flood plain management regulations; it may not show all areas subject to flooding in the community or all planimetric features outside special flood hazard areas.

For adjoining map panels, see separately printed Index to Map Panels.

Upon completion of technical floodplain studies, designation of appropriate flood boundaries, and adoption of floodplain regulations that meet NFIP minimum standards, a community is eligible for the NFIP "regular phase." Regulatory standards for the regular phase are more specific and more stringent than for the emergency program (see accompanying box for details of NFIP regulations). Entry into the regular program qualifies local property owners for full flood insurance coverage at actuarial rates that vary according to the degree of risk.

Insurance Rate Differentials. The variable rate structure for flood insurance premiums is another important component of the regular program of the NFIP. Flood hazard areas are divided into different zones, based on the degree of hazard. The rate for insurance then varies according to the zone and to the elevation of the building in relation to the base flood elevation.

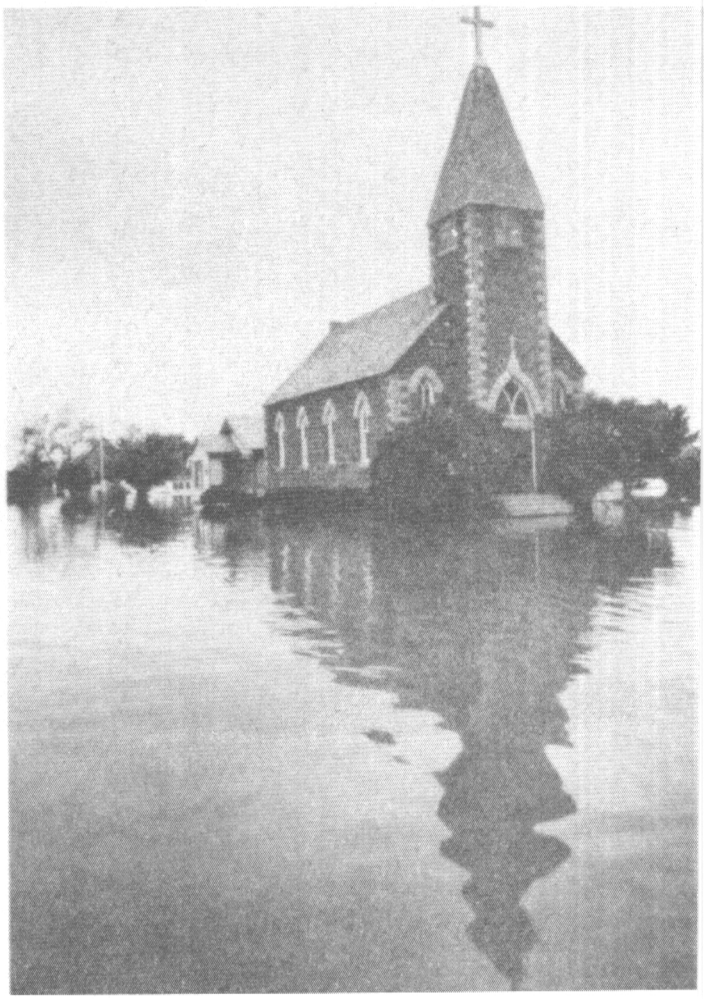
This variable rate structure adds a dimension to the restrictive element of the program by providing an incentive in fringe areas to increase safety beyond the regulatory minimum. Designers should be cognizant not only of the minimum standards, but also of the immediate and longterm economic benefits to the client that are provided by the rate differentials.

Local Planning and Floodplain Management

With the NFIP as incentive, nearly 17,000 communities around the country have begun to implement floodplain management through their local planning process. The principal tool for achieving this objective is the traditional zoning ordinance, which is used to prohibit and regulate development in designated flood hazard areas. Zoning is supplemented by subdivision regulations, which provide an administrative review to ensure that a project meets specified development standards. Of particular interest in this regard is the provision of public facilities, roads, and utilities in a manner that will not contribute to flood problems.

Innovative Planning Tools. In addition to traditional zoning and subdivision regulations, some communities use innovative planning techniques to address the specific problems of flooding. Notable here is the

After completion of detailed surveys, floodplain management regulations are implemented using Flood Insurance Rate Maps (opposite page, above) and Flood Boundary and Floodway Maps (opposite, below).



Department of Housing and Urban Development

American Red Cross

National Flood Insurance Program

The National Flood Insurance Program (NFIP) makes flood insurance available to individual property owners if, and only if their local government jurisdiction (i.e., city or county) participates in the NFIP and implements a program for floodplain management.

NFIP—Emergency Phase

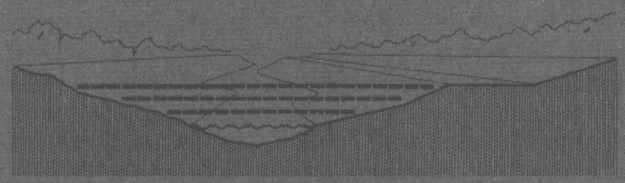
When a local government enters the initial emergency phase of the NFIP it must adopt regulations to provide preliminary control of development in flood-prone areas. These regulations must:

- Require building permits for all proposed construction.
- Require a review of building permit applications to ensure that new construction or substantial improvements* to existing buildings are reasonably safe from flooding.
- In flood-prone areas, as defined by a Flood Hazard Boundary Map, require:
  - —Design and anchoring to prevent flotation, collapse, or lateral movement of the structure
  - —Use of construction materials and utility equipment that are resistant to flood damage
  - —Use of construction methods and practices that minimize flood damage.
- Require a review of subdivision proposals and other proposed new developments to ensure that:
  - —All such proposals are consistent with the need to minimize flood damage.
  - —All public utilities and facilities, such as sewer, gas, electric, and water systems are located and constructed to minimize or eliminate flood damage.
  - —Adequate drainage is provided to reduce exposure to flood hazard.
- Require that new or replacement water supply systems and/or sanitary sewage systems be designed to minimize or eliminate both infiltration of flood waters into the systems and discharges from the systems into flood waters, and require that on-site waste disposal systems be located to avoid impairment of them, or contamination from them, during flooding.

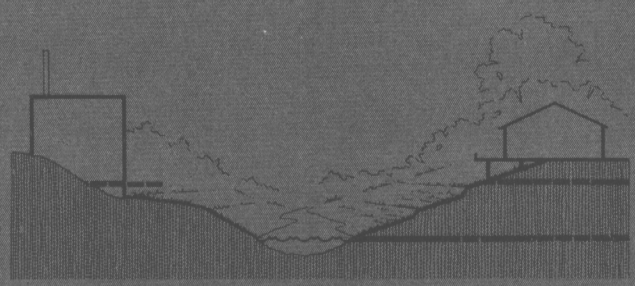
NFIP—Regular Phase

After detailed surveys and technical studies have provided more precise information on flooding characteristics, the local community must transfer to the regular phase of the NFIP. This move requires adoption of more stringent measures governing development in flood-prone areas and must include the following minimum regulations, which supplement those of the emergency phase.

- Residential buildings, either new construction or substantial improvements to existing structures, must have the lowest floor, including basements, above the regulatory base flood elevation (BFE).
- Nonresidential buildings, either new construction or substantial improvements to existing structures, must have the lowest floor above the BFE or be floodproofed up to the same elevation.
- A regulatory *floodway* must be designated, and in this area no new construction or substantial improvement to existing buildings can be permitted.
- Fill or encroachments are prohibited from the designated floodway.
- Mobile homes cannot be placed within the designated floodway, except in existing mobile home parks.



Flood magnitudes are frequently described in relation to the frequency with which a certain level of flooding is likely to occur.



Buildings in a riverine setting should be located above the Base Flood Elevation (BFE).

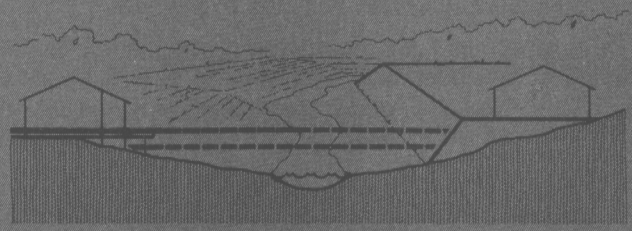
Coastal High Hazard Areas

Coastal High Hazard Areas are analogous to riverine floodways in that these areas are immediately adjacent to water and are subject to the greatest threat during flooding. In such coastal areas, designated as V-zones on Flood Insurance Rate Maps (FIRMs), the following regulations must be adopted to supplement other requirements of the NFIP.

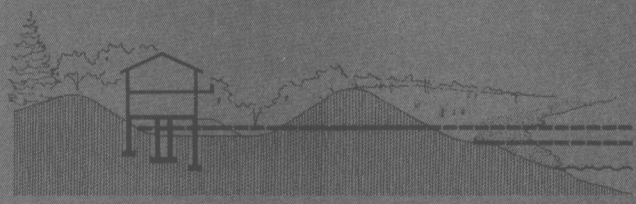
- New buildings or substantial improvements to existing buildings must be elevated above the regulatory BFE, which in V-zones is determined by the height of the wave crest that accompanies the storm surge. Such buildings also must be located landward of mean high tide.
- New construction must be anchored securely enough to pilings or columns to withstand high velocity waters and hurricane wave wash.
- New construction must be provided with open space below the lowest floor to allow unobstructed flow of flood water. This space must be free of obstruction or with open lattice walls that

use of performance standards, where development limits are based on measurable impacts. In a project in a flood fringe area where certain kinds of development are acceptable, development densities might be tied to maintaining minimum elevations, to a minimum impervious surface ratio to control water runoff, or to providing stormwater detention systems on the site.

Another technique that can be useful for a flood-prone area is Planned Unit Development (PUD). This method of cluster development is used predominantly for large-scale residential and/or commercial projects, and requires a special planning ordinance. With PUD, part of a given site is built on at a higher density than would otherwise be permitted, thus leaving the remainder of the site as open space. In a flood-prone area, the development could be clustered on the part of the site



Buildings in coastal areas should be located behind the dune or in the trough between dunes, and should be raised above the BFE.



The addition of fill material can impede the flow of flood water and may increase flooding levels, thus causing damage to buildings previously above the BFE.

will collapse under abnormally high tides without jeopardizing the main structure.

- Land fill cannot be used for structural support.
- Sand dunes and mangrove stands cannot be altered if they provide wave or flood protection.

As is often the case, regulations change as continuing research provides better information on the characteristics of flooding. This has happened regarding designation of the BFE in Coastal High Hazard Area V-zones, which until recently were determined by the elevation of the storm surge alone. They are now calculated on the basis of the wave crest height, which is the height of waves on top of the storm surge. The new regulations take effect in each local jurisdiction as soon as the FIRMs for respective areas have been updated to show the new BFE. In the interim the wave crest height can be estimated on a case-by-case basis with the help of FIA officials or their representatives. In any event, it is essential that designers consult with local officials to ascertain the status of regulations in their area before beginning any project. Existing variable insurance rates already provide an incentive to locate buildings at the higher elevations, but once the new requirements are in effect substantial insurance savings will accrue to conforming structures. A Federal Emergency Management Administration publication, *The Coastal Construction Manual,* takes these new requirements into account and should be used as a guide for designing in coastal areas.

Definition of Terms Used in NFIP

Base Flood Elevation—Base Flood Elevations (BFE) are associated with an intermediate level of flooding that is significantly less than the greatest floods that could occur. Flood magnitudes are expressed in various ways, the most common being to describe them in relation to the frequency with which a certain level of flooding is likely to occur. For example, a level of flooding that, according to statistical probability, will be equaled or exceeded every 50 years is termed a "50-year flood"; the flood level likely to be equaled or exceeded every 100 years is termed a "100-year flood"; and the level likely to be equaled or exceeded every 500 years is termed a "500-year flood." It is important to remember that these designations are based on probability.

The regulatory BFE is based on the probable 100-year flood or, in coastal areas, the wave crest height of the 100-year storm tide. These also are referred to as floods with a one-percent chance of occurrence in any given year. However, these designations should not be interpreted literally, since floods do not occur in predictable cycles. Another way to express flood probability is to say that a 100-year flood has a 26 percent chance of occurring during the life of a 30-year mortgage. It is also noteworthy that a local jurisdiction may adopt requirements more stringent than the NFIP.

Coastal High Hazard Areas—the area immediately adjacent to the ocean and subject to high velocity waters, including but not limited to hurricane wave wash, storm surges, and tsunamis. National Flood Insurance Program regulations for Coastal High Hazard Areas, also known as V-zones, apply where tides, storm waves, and local geographic characteristics combine to produce a breaking wave of three feet or more.

Encroachment- any physical object in a floodplain that hinders the passage of water or otherwise affects flood flows.

Flood proofing- any combination of structural provisions and/or other modifications incorporated in individual buildings or properties subject to flooding, primarily for the reduction or elimination of flood damages (see Chapter 5 for details).

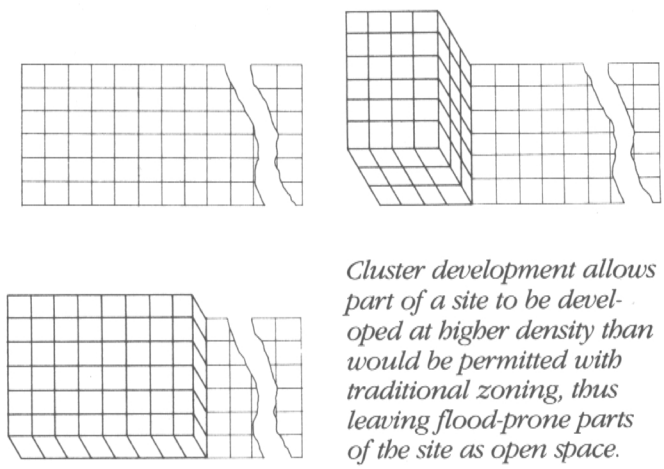
Floodway- the channel of a river or other watercourse and the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than a designated height.

Substantial Improvements- any improvement costing more than 50 percent of a structure's current market value.

that is safe, leaving the flood-prone part free of buildings but still usable as recreation space or parking.

Any of various local planning techniques can be used to control development to reduce flood damage. The designer should refer to these regulations to identify both restrictions that will apply to proposed buildings and opportunities that may be presented by planning regulations such as the PUD ordinance. The local planning agency is also a primary information resource for the designer. In addition to zoning maps, it will often provide access to other data that is useful in identifying flood hazards, such as is contained in the variety of technical floodplain studies.

Building Codes. Building codes are used infrequently to address the specific problems of flood damage. However, there are elements of design that



Cluster development allows part of a site to be developed at higher density than would be permitted with traditional zoning, thus leaving flood-prone parts of the site as open space.

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Though this house remained intact, the force of a coastal flood knocked it off its foundation, causing extensive damage.

conceivably can be included in building codes in regard to flooding. For example:

- Codes may prohibit basements in certain areas or can require that basements be floodproofed to protect against damage.
- Structural reinforcements, waterproofing, or other protective measures may be required for structures with the first floor or basement below the base flood elevation.
- Buildings may be required to be anchored to prevent flotation during flooding.
- Building materials for use in flood-prone areas may be specified.

One of the national model codes does make general references to flood-related standards. The Building Officals and Code Administrators (BOCA) model code includes sections requiring structural integrity of foundations, walls, floor slabs, and retaining walls that might be subjected to water pressure. This model code (see the Resource Index for specific sections of the BOCA model code) is used in many parts of the country, often being adopted by reference. Other communities may have similar or more stringent requirements, and the designer should consult with local or state building officials to ascertain what codes are in effect.

State Programs

Some states have regulations applying to development in floodplains, along river channels, or in coastal zones. These regulations may be parallel to local requirements or in addition to them. The appropriate state government departments responsible for floodplain management, water resources, building codes or coastal zone management should be consulted prior to design of any project in a flood hazard area (state agencies are listed in the Resource Index).

Each state has designated a State Coordinating

Agency to assist in the implementation of the NFIP. This agency is a focal point for information on flood insurance, floodplain management, and coordination of the diverse state agencies with responsibilities for riverine and coastal floodplains. The authority of each state's coordinating agency varies, and can best be determined through direct contact. These agencies can be important sources of physical data, information on community eligibility for flood insurance, state regulations, references to other agencies, and, in some instances, technical assistance (State Coordinating Agencies are listed in the Resource Index).

Regional Jurisdictions

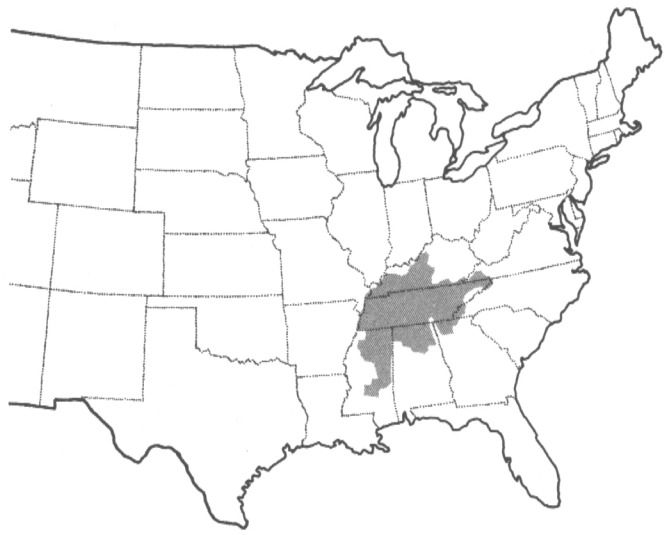
Several regional jurisdictions, both governmental and quasi-governmental, have taken an interest in floodplain management. Foremost of these is the Tennessee Valley Authority (TVA), the federally owned corporation established in 1933 to conduct a unified program of resource development for the economic growth of the Tennessee River Valley. It has played a leading role in both structural and nonstructural aspects of floodplain management, and is a particularly valuable source of physical data and technical assistance to professionals and communities in the region.

Within the thirteen-state Appalachian region, the Appalachian Regional Commission has been established as a cooperative federal-state entity to analyze regional problems and coordinate federal and state initiatives in Appalachia. It has addressed flooding and other natural hazards problems, and is a valuable source of economic, physical, and social data for its region.

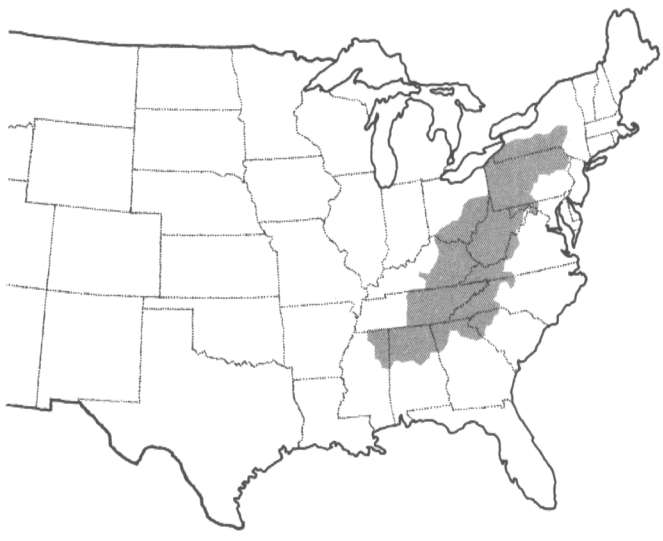
Nine federal and state River Basin Commissions conduct a similar range of policy, planning, research, and coordinating activities in their respective regions, working closely with the U.S. Water Resources Council.*

Federal Agency Requirements

A variety of federal programs other than the NFIP deal with flooding issues. For example, the U.S. Army Corps of Engineers requires permits for development adjacent to major river channels or flood control projects. For many projects it is necessary to submit an Environmen-



Tennessee Valley Authority jurisdiction



Appalachian Regional Commission jurisdiction

**Delaware River Basin Commission, Great Lakes Basin Commission, Mississippi River Commission, Missouri River Basin Commission, New England River Basin Commission, Ohio River Basin Commission, Pacific Northwest River Basin's Commission, Susquehanna River Basin Commission, and Upper Mississippi River Basin Commission*

tal Impact Statement prior to project approval by a governing body or agency. And, on all projects funded directly by the federal government, Presidential Executive Orders require special consideration of flooding issues (E.O. 11988) and protection of wetlands (E.O. 11990). Such requirements should be checked by referring to the appropriate federal agency (see Resource Index for list of agencies and their regional offices).

Flood Hazard Data

Flood hazard data identifies essential flood-related factors for both the general region and the specific site. This basic data helps determine the degree of hazard that is likely at any proposed site, identifies the expected impacts of proposed development on future flooding severity, and provides the necessary information for evaluating and choosing mitigation strategies.

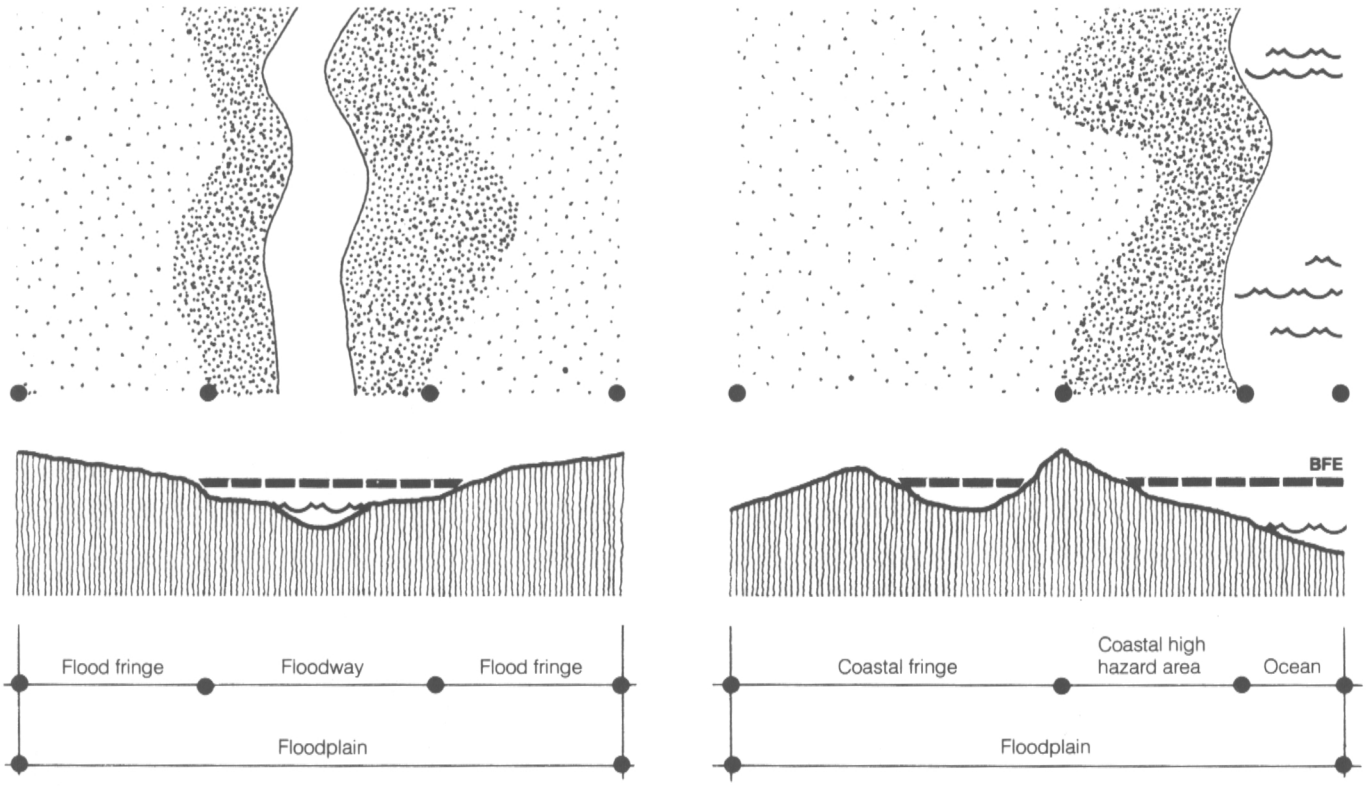
Hydrologic Data

Much of the data relevant to damage mitigation concerns the flow of water associated with the various stages in the hydrologic cycle. A variety of components of the natural system—both riverine and coastal—combine to cause flooding. The designer must analyze these components to understand the threat from flooding that is to be mitigated in design.

Hydrologic data is available from numerous sources. Various governmental agencies carry out floodplain technical studies, the scope and content of which varies according to the needs of each agency. General information on flooding characteristics, as well as detailed analysis of flood boundaries, levels, velocities, etc. are avail-

Agencies / Data type	Coastal Surveys & reports	Flood control measure	Flood hazard reports	Flood insurance studies	Floodplain information reports	Flood records & probabilities	Floodplain technical studies	Hydrologic atlases	National Flood Insurance program regulations	State floodplain regulations	Technical assistance	Topographic maps	Zoning ordinances & maps
Local government planning agency or municipal engineer		●	●			●		●	●				●
State floodplain mangement coordinating agency		●	●			●		●	●	●			
State office of coastal zone management	●					●			●				
Federal emergency management agency		●	●					●		●			
National Oceanic and Atmospheric Administration (Department of Commerce)	●	●	●		●								
Soil Conservation Service (U.S. Dept. of Agriculture)		●	●		●								
U.S. Army Corps of Engineers (Department of Defense)		●	●	●	●					●			
U.S. Geological Survey (Department of the Interior)			●		●	●	●				●		
Regional authorities (e.g. TVA)		●	●		●	●				●	●		

Federal, state, and local sources of information on flooding and floodplain management (see Resource Index for detailed listings of information sources).



The regulatory floodplain consists of two components. The riverine floodplain (left) consists of the floodway and the flood fringe. Corresponding designations for the coastal floodplain (right) are the coastal high hazard area and the coastal fringe.

able for all areas of the country and for many specific sites. The accompanying matrix identifies relevant agencies and notes the flood-related data that each agency is usually able to provide.

In cases where agencies cannot provide the information or where existing reports do not include a particular site, hydrologic specialists can develop the required information through site-specific surveys. Some large design firms have staff engineers capable of completing hydrologic studies, or such specialists can be retained as consultants for specific projects as required.

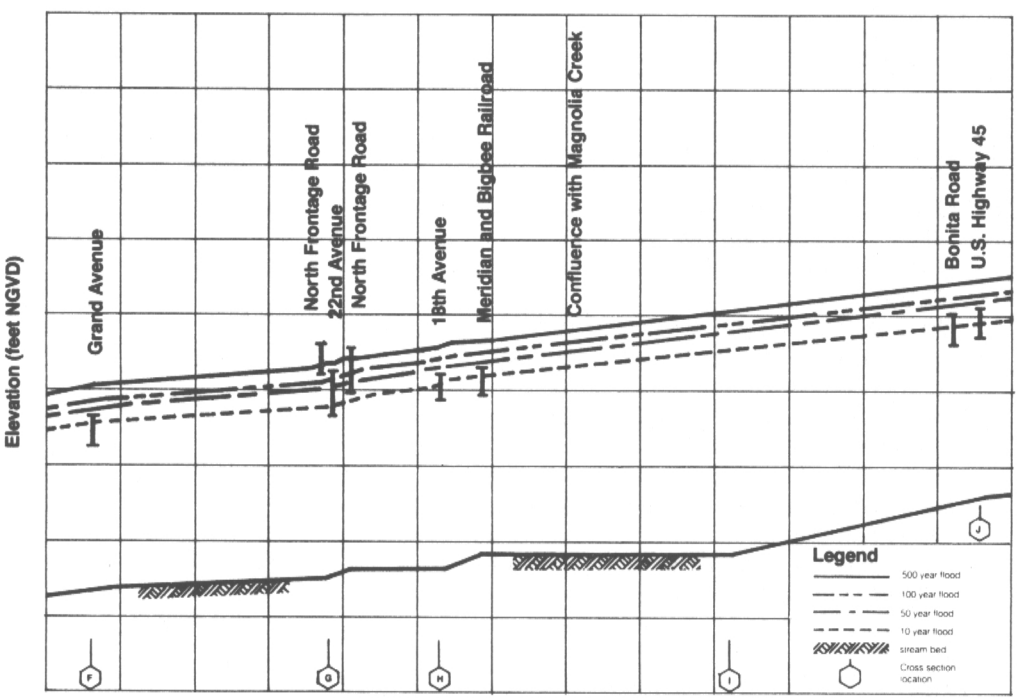
Data concerning hydrologic conditions at the proposed site should include the following elements.

Flood Hazard Boundaries. Boundaries for the different degrees and types of flooding, including floodways, floodway fringe, coastal high hazard areas, coastal fringe, and shallow flooding areas, must be identified. Flood hazard boundaries are most significant because they determine the specific flood hazard zones that are part of a proposed development site or that will influence development on the site. In addition, boundaries indicate where floodplain management regulations and flood insurance requirements apply to the site. Flood hazard boundary data can be obtained from floodplain maps or be developed from topographic maps, zoning

maps, aerial photographs, and related hydrologic data.

Flood Depths. Flood depths are determined by the difference between water surface elevation at times of flooding and normal ground surface elevations. This information is important both in determining the elevations at which flood damage is likely to occur and in defining the appropriate building elevations for flood insurance and floodplain management regulations. Flood depths also influence the hydrostatic forces that are in effect during flooding, including the horizontal loads that can cause lateral displacement or overturning, and the vertical loads that can cause uplift, flotation, or downward pressure on roofs. Flood depth data is available from various technical studies that include flood elevations, water surface profiles, or stream and coast cross-sections. In the absence of official reports, information on flood depths can be obtained from site survey and historical records.

Flood profiles—Sowashee Creek



Stream distance in miles above confluence with Okatibbee Creek

A flood profile (or water surface profile) such as this one identifies the elevation of various levels of flooding for a specific stream channel.

Flood Water Velocity The average and maximum velocity of flood water is important in determining hydrodynamic forces, which influence horizontal loads in excess of hydrostatic loads. Velocity also affects the magnitude of debris impact loads (i.e., force of floating objects carried by flood waters), and can increase ero-

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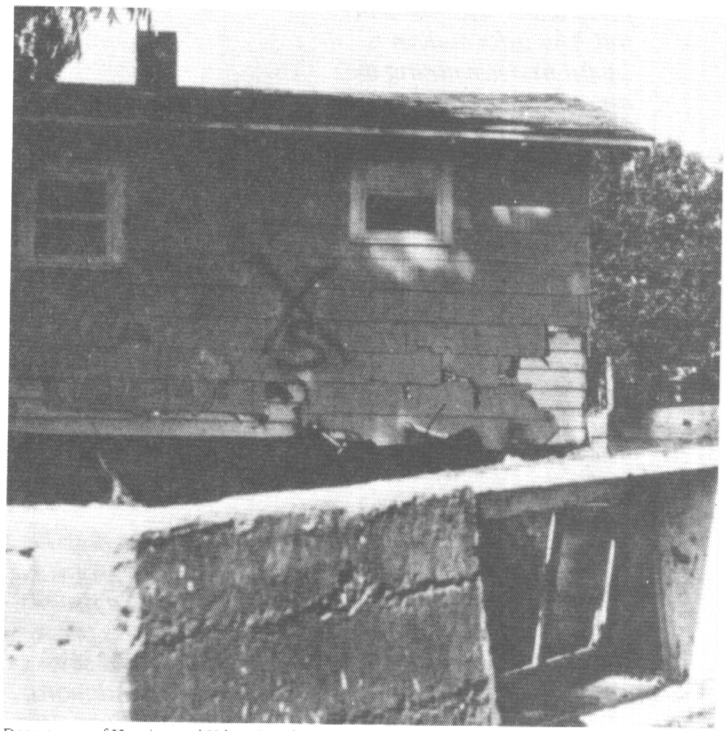
Flood water velocity produces lateral forces that can cause scour and result in collapse of foundations (above left), increase the magnitude of debris impact loads (below left), and dislocate buildings from their foundations (below).

U.S. Army Corps of Engineers



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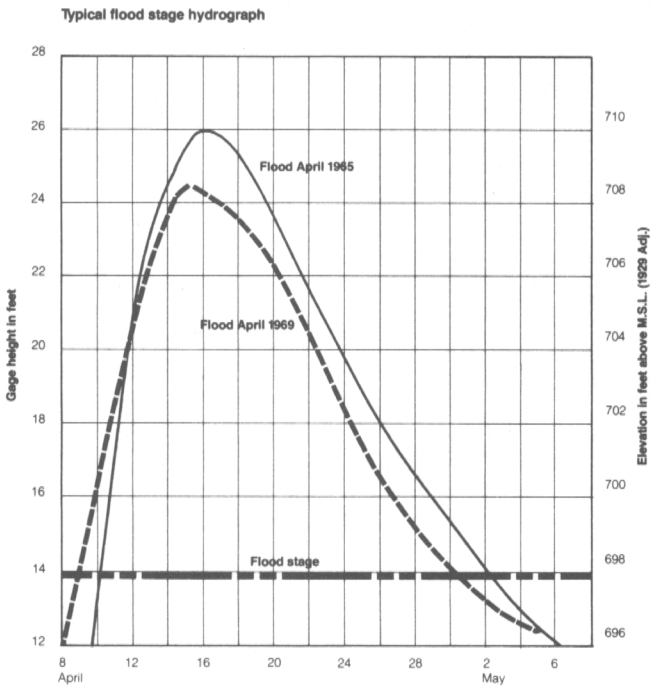
sion and affect soil stability on slopes. Data on water velocity is available from the various floodplain technical studies or can be determined by special hydrologic studies.

Advance Warning. The amount of advance warning prior to flooding is determined largely by the speed with which flood waters rise, which depends on the rate at which water enters the system and the topography of the watershed. The topography of the watershed influences warning time by affecting the rate of storm water runoff. A watershed with flash flooding characteristics will allow very little warning, while a larger and flatter drainage basin will usually result in slower rise and more warning time. Warning time is important in planning for emergency evacuation, as well as in determining the feasibility of incorporating waterproofing tech-



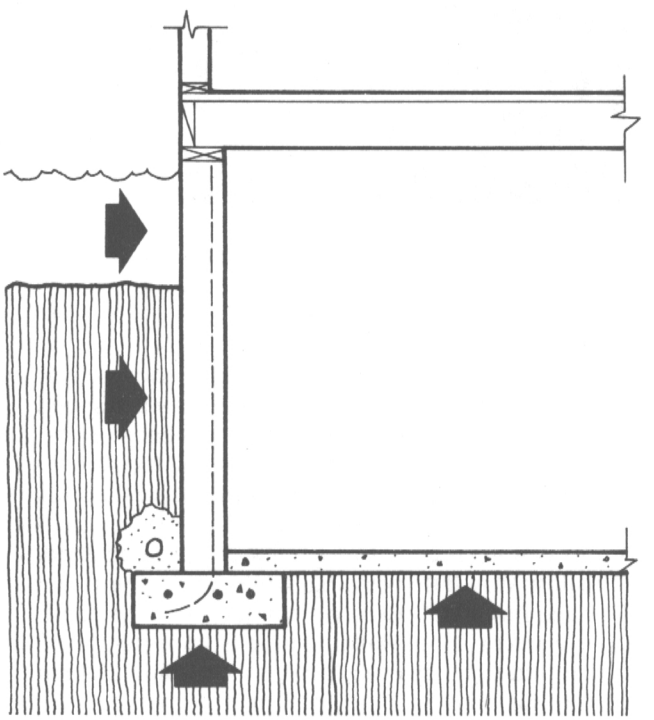
A hydrograph charts water depth in relation to time, indicating the rate at which flood water will rise and fall. This information is useful in determining the amount of advance warning likely and the duration of flooding.

niques that require time to install. It is also a factor in designing systems for wet floodproofing and influences the design of drainage systems.

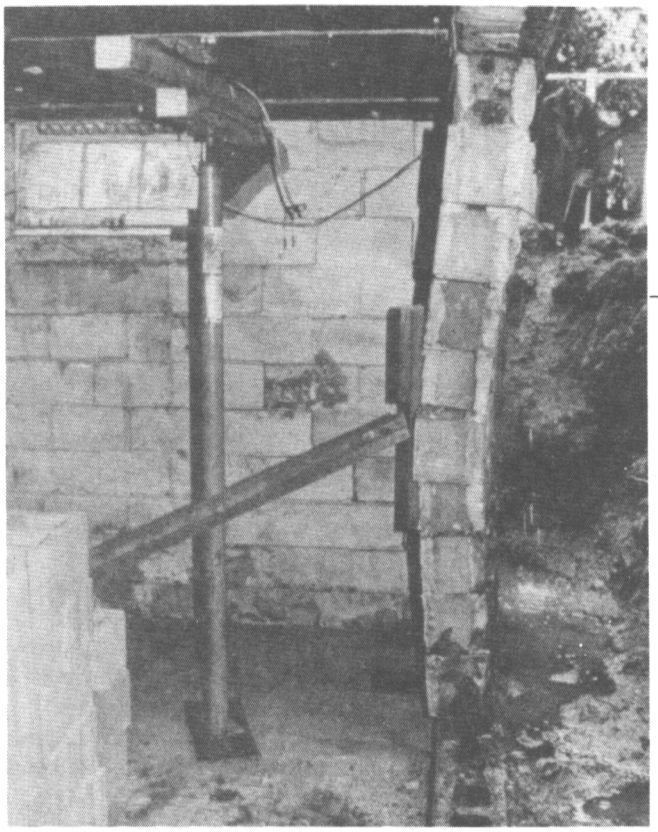
Data on rates of rise and fall of water is typically presented in the form of a hydrograph, which charts water depth over time, and is part of many of the technical reports. In addition to the usual sources, data on warning time may be available from local civil defense offices or the historical records of local police or fire departments.

Duration of Flooding. The duration of flood inundation, which is a function of the rate of rise and fall of water, has several important influences on design. Duration influences the saturation of soils and building materials, the amount of seepage, and the length of time that facilities might be inaccessable or inoperable, which might have major economic impacts. These factors can affect design decisions on building orientation, configuration, and use of the various floodproofing techniques. The various floodplain technical studies and historical records are the sources for this information.

Frequency of Flooding. The frequency with which flooding occurs is of course a major factor in determining building locations. It can also be important in considering techniques for floodproofing, particularly those that require installation prior to each flood event. For



Water pressure, both above and below the ground, is increased by the rise of flood water. This pressure causes increased stress on buildings' foundations, footings, and floor slabs.



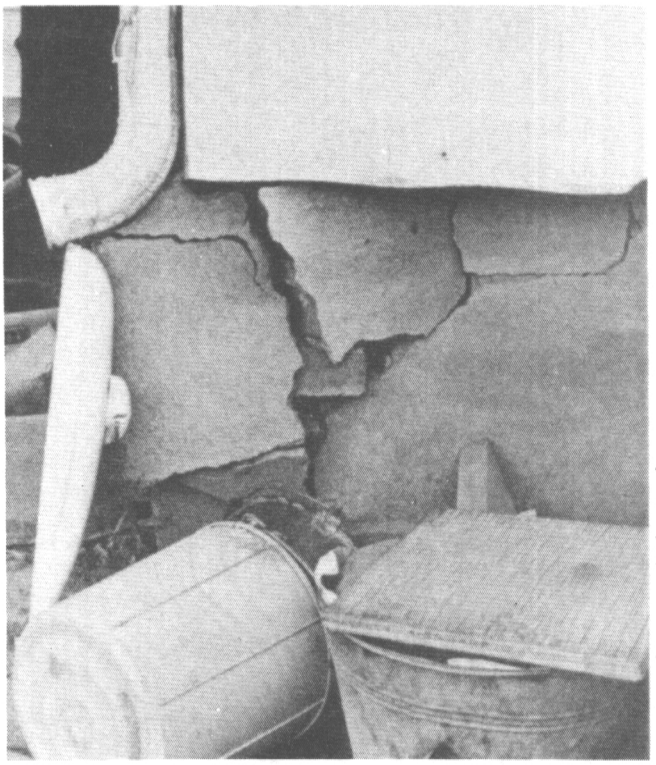
David Valdez, Department of Housing and Urban Development

example, frequent use of temporary protective coverings over vulnerable doors and windows requires that such coverings be easy to put in place and remove. Frequency of flooding also indicates the need for special access to or from the site if flooding is anticipated to be a common occurrence.

Climate and Weather. Climate and weather are factors in predicting the frequency and type of precipitation that might be common to a particular area, which, in turn, influences flooding severity. For example, a propensity for cloudbursts or heavy snowfall will indicate a need for dealing with quick water build-up in the design of a given project. Seasonal variations might also be a consideration in this respect. Data on climate and weather is obtainable from the records of the local office of the National Weather Service, as well as from local newspapers, police, and civil defense officials.

Ground Water Levels. Ground water levels interact with the effects of precipitation and storm water runoff to help determine the water pressure on footings, foundation walls, and floor slabs during flooding. With high ground water levels, the uplift forces associated with flooding will occur more quickly and more frequently, and should be accommodated in the design of all structures on the proposed site.

Flood Control Measures. Existing flood control works will have been accounted for in the basic flood hazard data such as flood boundaries and flood depths. However, the designer still needs to be aware of the limits of the control works and of the effects on the proposed site if water does exceed the design limits. Beyond these issues, the designer should know of any proposed flood control structures that will alter local flooding characteristics. If such devices are proposed,



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These examples of structural damage illustrate the possible effects of water pressure associated with flooding.

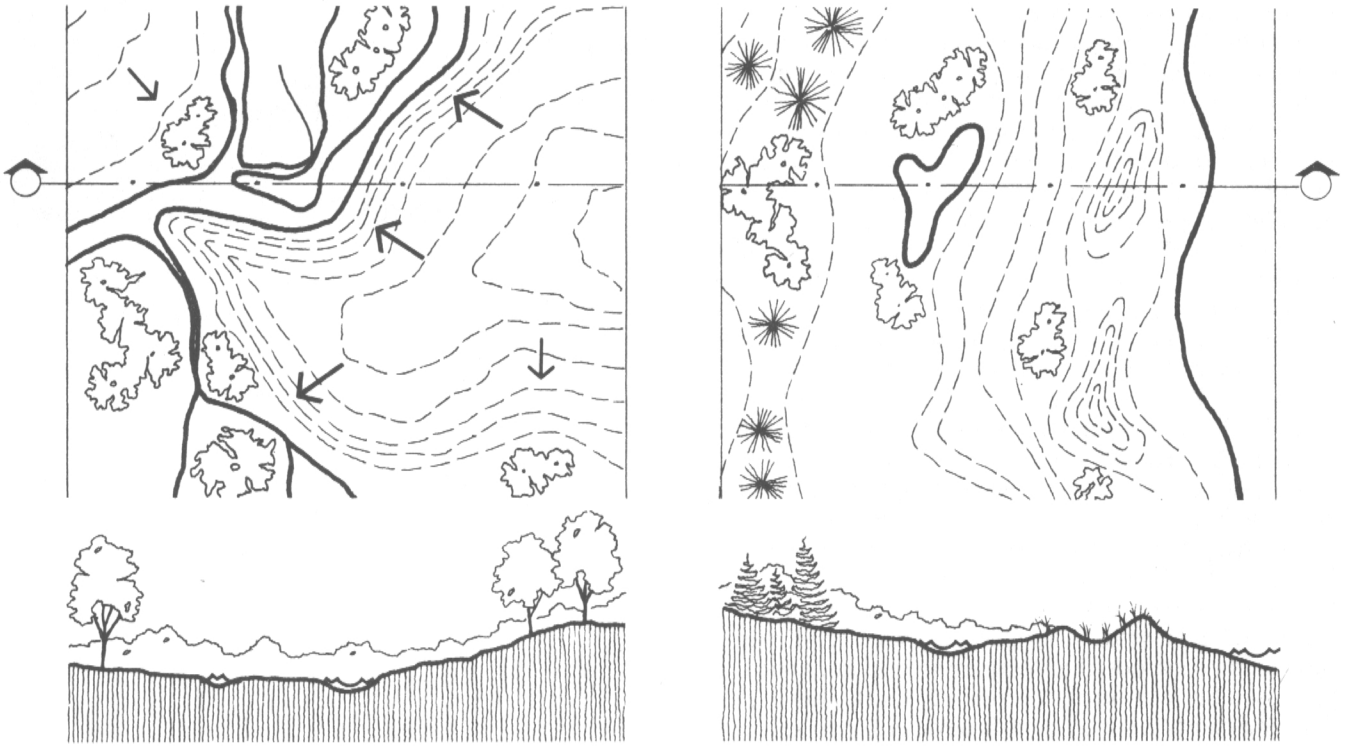
information from the relevant implementing agency or from the Federal Emergency Management Agency (FEMA) can help determine the probability of the control project being implemented and can give an estimate of its expected effects and completion date.

Site Characteristics

In addition to hydrologic data, a number of specific site characteristics affect flooding and the choice of strategies for flood damage reduction. As with hydrologic data, local planning offices and various federal agencies are primary sources of information on site characteristics. In addition to these resources, much of the site analysis depends on site surveys, both visual and technical, by design staff and professional consultants. Relevant site characteristics include the following.

Physiographic Features. Physiographic features on the site, such as the location of stream channels or meandering channels, drainage patterns, wetlands, sinkholes, and erosion patterns affect flooding. These natural features should be identified to indicate which areas of the site should be avoided or protected during development. Such features will affect orientation, distribution, and density of built elements on the site, and will help identify advantages and constraints to be considered in site development. Physiographic features can be

Physiographic features must be analyzed to determine which areas of the site should be avoided or protected during development. In both riverine (left) and coastal (right) environments attention should focus on stream channels, drainage patterns, wetlands, and existing vegetation.



Soil Types

Division	Soil Description	Value As A Material Foundation	Drainage
Gravel and Gravelly Soils	Well graded gravel, or gravel/sand mixture; little or no fines	Excellent	Excellent
	Poorly graded gravel, or gravel/sand mixtures; little or no fines	Good	Excellent
	Silty gravels, gravel/sand/silt mixtures	Good	Poor
	Clayey sands, sand/clay mixtures	Good	Poor
Sand and Sandy Soils	Well graded sands, or gravelly sands; little or no fines	Good	Excellent
	Poorly graded sands, or gravelly sands; little or no fines	Fair	Excellent
	Silty sands, sand/silt mixtures	Fair	Fair
	Clayey sands, sand/clay mixtures	Fair	Poor
Silts and Clays	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands, or clayey silts with slight plasticity	Fair	Poor
	Inorganic silts of low to medium plasticity, gravelly sands, silty clays, lean clays	Fair	Impervious
	Organic silt/clays of low plasticity	Poor	Impervious
	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	Poor	Poor
	Inorganic clays of high plasticity, fat clays	Very Poor	Impervious
	Organic clays of medium to high plasticity, organic silts	Very Poor	Impervious
Highly Organic Soils	Peat and other highly organic soils	Not Suitable	Poor

Soil characteristics must be analyzed to determine the soil's drainage characteristics and its value as foundation material.

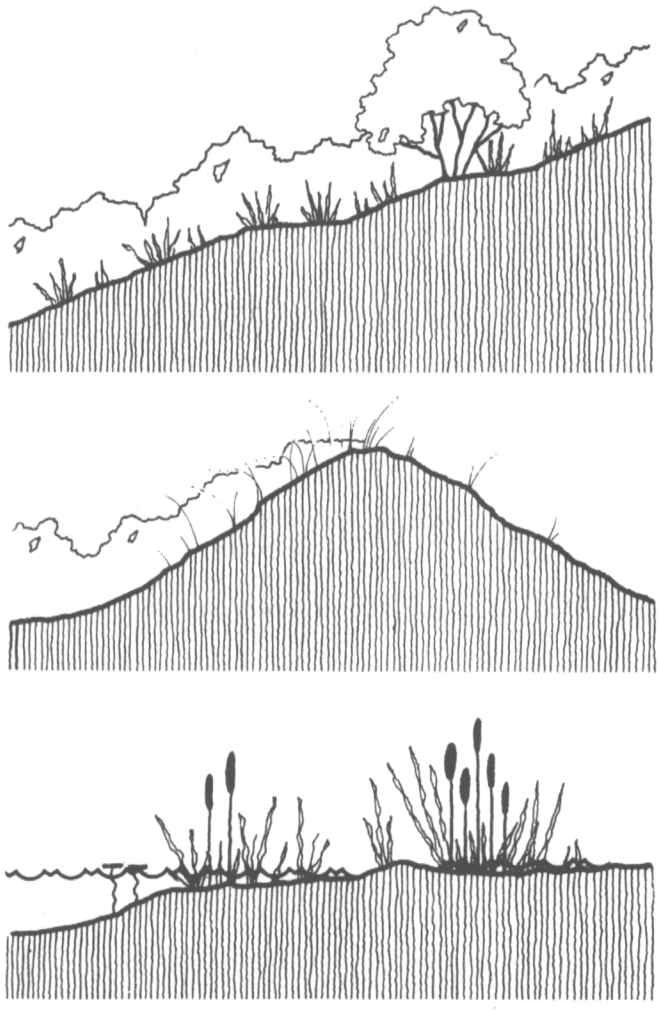
identified by referring to topographic maps and floodplain technical studies, as well as by conducting detailed site surveys.

Site Topography. Identification of topographic elements such as slopes and ground elevations is most important in determining the buildable portion of a site. Topographic data also indicates erosion potential and the need for, and feasibility of, using fill material to enhance the site for construction.

Soil Characteristics. Soil characteristics affect flood damage reduction in several ways. The permeability of soil determines the degree of water absorption, which influences the rate of storm water run-off, erosion, and ground water storage. Soil characteristics also determine the feasibility and design specifications for the use of land fill to elevate buildings, the use of backfill around foundations, and the construction of earth berm levees on the site. Finally, soil analysis will indicate the necessary depths for footings and pilings, as well as piers and columns used to elevate buildings.

Soil data can often be obtained from the U.S. Department of Agriculture's Soil Conservation Service in the form of maps, elevations, tables, and reports, or can be collected by design staff and consultants as part of site-specific surveys.

Stability of Slopes. The combination of topography and soil characteristics determines the stability of slopes on the site and affects design decisions in several ways. Slope stability affects the choice of the actual building site, the use of fill material, and the design of founda-



Vegetation is an important part of controlling water runoff. It helps prevent erosion and reduces the flow of surface water on slopes (top). It also stabilizes dune composition in coastal areas (center) and protects wetland areas (bottom).

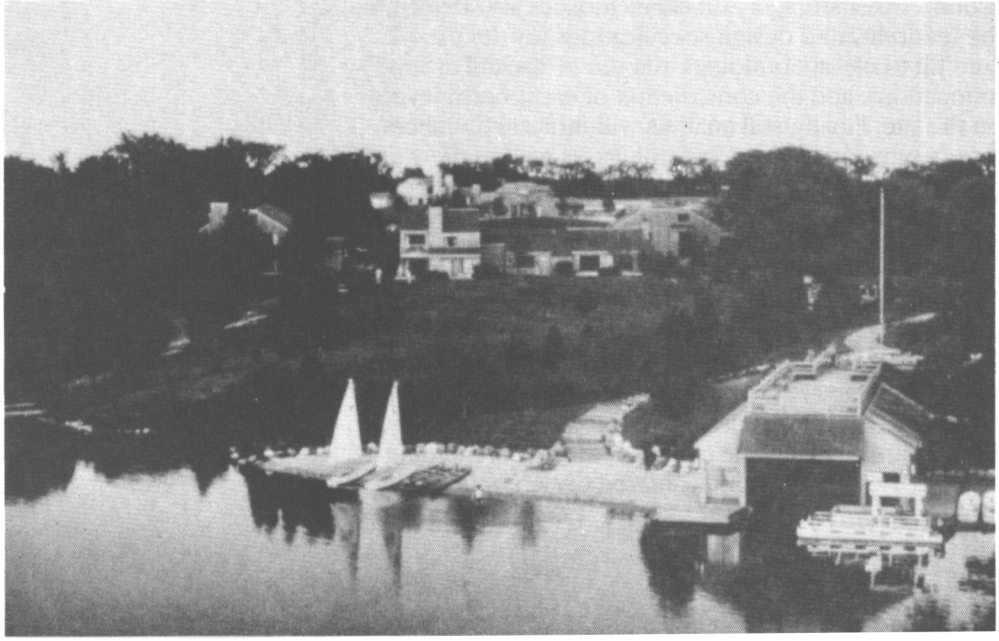
tions, footings, and pilings. Slope stability also influences erosion, which determines the need to use protective techniques such as terracing, planting, or other forms of ground cover.

Vegetation. Both existing and potential vegetation on a proposed site affect the choice of flood damage reduction strategies. Vegetation aids in the control of storm water runoff and helps discourage erosion. Site surveys carried out by design staff or consultants should identify how existing vegetation is related to flooding and how vegetation can be used in site development to minimize flood-related losses.

Water Storage. Water storage, either temporary or permanent, is another factor in controlling storm water runoff. Storage devices can be used to hold excess runoff until it can be released gradually into the watershed system, thereby avoiding the rapid accumulations that cause flooding. Additionally, stored water can aid in recharging ground water levels and, in some instances, provide environmental amenity. Site analysis should identify where water collects on the site prior to development, such as in natural surface depressions, and should indicate how water can be detained after development. This information can be obtained from topographic maps, surface profiles, and site surveys.

Existing Development

Existing development at the site and in the surrounding region also influences design in flood-prone areas. The intensity and type of development adjacent to the proposed site will influence the movement of water through the hydrologic cycle, and thus influence flooding at the site. With a high level of development intensity in the region there is likely to be more surface runoff of



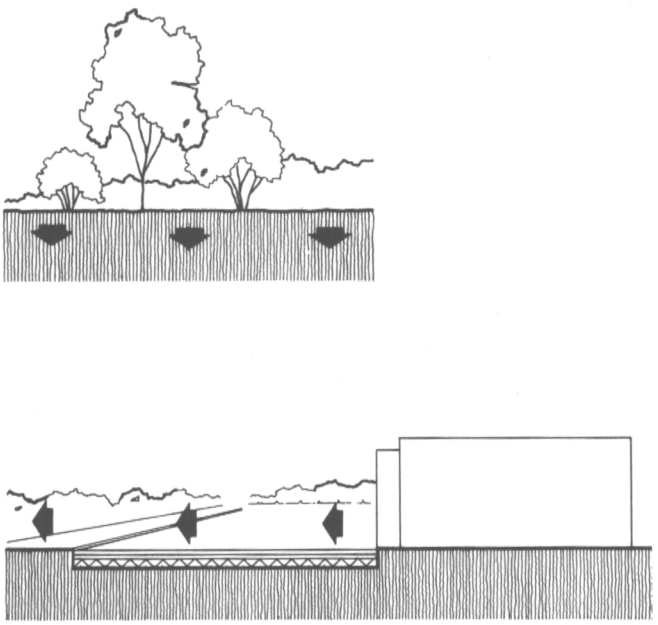
Water storage can be an important aid in controlling water runoff.

storm water, which will increase the volume of water entering the site from upstream.

Likewise, the designer must gauge the impact of the proposed project on the existing built environment and the cumulative impact of existing and new development on the natural environment. Analysis of these elements in relation to flood potential can increase the designer's sensitivity to the importance of maintaining a balance with the natural system, and can help minimize flood losses, both on-site and downstream.

Existing Infrastructure. In addition to general consideration of the existing development, specific attention should be given to the location and design of existing streets and utilities. The location of utilities is one aspect to consider in making buildings waterproof and affects maintenance of essential services during floods. Streets and utilities are important in determining site use layouts, and should be analyzed in reference to building locations and access to and from the site during floods.

After all information regarding flooding, regulatory requirements, and related design requirements is collected, it is synthesized in the design program: flood-related constraints are identified, building requirements are outlined, and the buildable portions of the site are determined. The next step is to develop design alternatives, drawing on the full range of available techniques for reducing flood damage, within the context of the overall design program.



Permeability influences water runoff. An undeveloped site (top) is highly porous and allows water to percolate into the soil. Developed sites with most of their surfaces covered with nonporous materials (bottom) do not allow this percolation, resulting in greater runoff.

Literature Resources

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Summary Table:
Design Analysis for Flood Damage Reduction

Regulatory Information

Information Required	Purpose or Implications of Data	Possible Forms of Data	Potential Sources of Data
• National Flood Insurance Program (NFIP)	• Requires local communities to implement floodplain regulations. • Sets minimum standards for floodplain regulations. • Prohibits federal funding for projects in violation of floodplain regulations. • Prohibits federal loan guarantees for projects in violation of floodplain regulations. • Establishes flood insurance rate differentials for properties in flood-prone areas.	• Program regulations • Insurance rate information and tables • Flood Insurance Studies • Flood Maps Section 1362 Guidelines	• Federal Insurance Administration • Federal Emergency Management Agency • State Floodplain Management Coordinating Agency • Local Government Planning Agency
• Local Government Planning Programs	• Implements floodplain regulations. • Determines local floodplain regulations based on NFIP guidelines (includes zoning and subdivision regulations, performance standards, Planned Unit Development ordinances, building codes, etc.) Note: Local regulations can be set at a higher standard than NFIP minimum standards, depending on local needs and circumstances.	• Planning and Zoning Ordinances • Zoning Maps • Building Codes	• Local Government Planning Agency • Local Government Engineer • Building Code Officials
• State Floodplain and Coastal Zone Programs	• Provides statewide floodplain development regulations and guidelines. • Regulates development in coastal zones. • Coordinates implementation of NFIP in local jurisdictions and in areas where multiple state agencies have an interest in flooding. • Clearinghouse for Floodplain Management Information.	• State program regulations • State development guidelines	• State Floodplain Management Coordinating Agency • State Office of Coastal Zone Management • State Office of Natural or Water Resources
• Regional Planning Restrictions or Guidelines	• Can provide additional regulations and guidelines for regional jurisdictions. • Coordinates activities of different agencies within the region. • Source of information and, in some cases, technical assistance.	• Program regulations • Development guidelines	• Regional Authorities (e.g., Tennessee Valley Authority, Appalachian Regional Commission, etc.) • Regional Planning Commissions • River Basin Commissions
• Federal Agency Requirements and Guidelines (other than NFIP)	• May include regulations relating to development in flood-prone areas (e.g., Corps of Engineers permits for development on navigable rivers). • May involve federal funding, the use of which is restricted in flood-prone areas. • Projects may require federal approval for development in flood-prone areas (e.g., Environmental Impact Statements).	• Program regulations	• U.S. Army Corps of Engineers • Environmental Protection Agency • Federal Emergency Management Agency • State Floodplain Management Coordinating Agency • Local Planning Agency

Hydrologic Data

Information Required	Purpose or Implications of Data	Possible Forms of Data	Potential Sources of Information
• Flood Hazard Boundaries	• Determines where floodplain regulations, insurance, and federal financing restrictions apply. • Determines specific flood hazard zones. • Determines variable flood insurance rate zones.	• Flood Hazard Boundary Maps • Flood Insurance Rate Maps • Flood Boundary and Floodway Maps • Hydrologic Atlases • Local Zoning Maps • Flood Insurance Studies	• Local Government Planning Agency • Local Government Municipal Engineer • State Floodplain Coordinating Agency • State Office of Natural Resources • Federal Insurance Administration • Federal Emergency Management Agency • U.S. Army Corps of Engineers • U.S. Geologic Survey • Regional Authorities —Tennessee Valley Authority —Appalachian Regional Commission —River Basin Commissions • Hydrologic Engineering Consultants • Surveys by Professional Staff
• Flood Depths	• Indicates elevations at which flood damage is likely to occur. • Determines appropriate building elevations for meeting floodplain regulations and flood insurance restrictions and rates. • Indicates hydrostatic loads in flood-prone areas.	• Flood Elevations • Water Surface Profiles • Stream and Coast Cross-sections • Flood Insurance Studies	
• Flood Water Velocity	• Determines hydrodynamic loads in flood-prone areas. • Determines debris-impact loads in flood-prone areas. • Indicates potential for erosion and slope deterioration.	• Floodplain Technical Studies • Hydrologic Studies • Flood Insurance Studies	
• Warning Time	• Indicates importance of emergency evacuation as part of the design program. • Influences design of floodproofing techniques such as flood shields. • Influences design of drainage systems. • Influences design of wet floodproofing techniques.	• Hydrographs • Floodplain Technical Studies • Historical Records • Flood Insurance Studies	

Hydrologic Data

Information Required	Purpose or Implications of Data	Possible Forms of Data	Potential Sources of Information
• Duration of Flooding	• Affects seepage into buildings and saturation of soils and building materials. • Affects the length of time facilities might be inaccessible or inoperable. • Affects building design relative to orientation, configuration, and choice of floodproofing techniques.	• Floodplain Technical Studies • Historical Records • Flood Insurance Studies	• U.S. Department of the Interior Water and Power Resources Service (operates west of the Mississippi River.)
• Frequency of Flooding	• Influences site choice. • Affects choice of floodproofing techniques, especially those that require installation before every flood. • Indicates need for special access.	• Floodplain Technical Studies • Historical Records	
• Climate and Weather	• Indicates frequency and type of precipitation and, in turn, the type and magnitude of flooding that is likely.	• Weather Service Records • Historical Records	
• Ground Water Level	• Influences potential water pressure on footings, foundations, and floors. • Affects site design techniques for controlling water runoff.	• Geologic Surveys • Soil Analysis Reports	
• Structural Flood Control Measures (e.g., dams, levees, channel improvements)	• Existing measures can affect site if the limits of the flood control device are exceeded. • Proposed measures can, when implemented, alter basic flood data.	• Feasibility Studies • Design Specifications • Probability Reports	

Site Characteristics

Information Required	Purpose or Implications of Data	Possible Forms of Data	Potential Sources of Information
• Physiographic Features	• Affects location and magnitude of flooding on the site. • Identifies areas of the site that should be avoided or protected. • Affects orientation, distribution, and density of built elements on the site. • Identifies physical constraints and advantages for site development.	• Topographic Maps • Floodplain Technical Studies • Site Surveys	• Local Government Planning Agency • Local Government Municipal Engineer • State Floodplain Coordinating Agency • State Office for Natural Resources • Soil Conservation Service, U.S. Department of Agriculture • U.S. Geologic Survey • Regional Authorities • Hydrologic and Civil Engineering Consultants • Surveys by Professional Staff • U.S. Department of the Interior Water and Power Resources Service (operates west of the Mississippi River.)
• Topography	• Influences siting of buildings. • Indicates erosion potential. • Indicates need for, and feasibility of using, fill material on the site. • Indicates appropriate site design techniques for controlling water runoff.	• Topographic Maps • Floodplain Technical Studies • Site Surveys	
• Soil Characteristics	• Soil porosity influences the rate of water runoff and flooding potential. • Determines the feasibility and design specifications for use of fill material to elevate buildings, the use of backfill around foundations, and construction of earth berms. • Indicates required depth for footings, pilings, or columns.	• Soil Maps • Soil Analysis Reports • Site Surveys	
• Slope Stability	• Affects choice of building sites, the use of fill material, and the design of foundations, footings, and pilings. • Influences erosion. • Indicates the need for terracing or ground cover to protect slopes.	• Analysis of combined effects of topography and soil characteristics • Site Surveys	
• Vegetation	• Aids in control of water runoff, and thus can be a factor in reducing flooding levels.	• Site Surveys	
• Water Storage	• Aids in control of water runoff, and thus can be a factor in reducing flooding levels. • Recharges ground water supplies.	• Geologic, soil, and hydrologic surveys • Site Surveys	